出國報告（出國類別：其他）

參加亞太地區無人機工作小組
第 3 次會議
出國報告書

服務機關：交通部民用航空局
姓名職稱：耿驊簡任技正、吳冠模約聘查核員
派赴國家：澳洲
出國期間：自 107 年 9 月 15 日至 9 月 21 日
報告日期：107 年 11 月 28 日

目　錄

圖目錄

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壹、目的

有鑒於世界各國遙控無人機之使用蔚為風潮且已發生數起對地面人員造成傷害之事件，未經核准進入空域無人機亦會對軍、民及公務航空器作業產生飛安風險，紛紛立法規管，民航局自 100 年 3 月起發布航空公報(AIC)，對國防、公務及以政府經費實施研究之遙控無人機作業予以規範。然展望未來 5 至 10 年間，無人航空器由軍用進入民用領域後，將對傳統有人航空器作業環境產生衝擊，無人航空器如何與載人航空器共存及可能衍生之各項公共安全議題，急需立法管理，行政院遂於 104 年 7 月指示，以修正「民用航空法」(以下簡稱民航法)方式對我國遙控無人機進行統一規範與管理。立法院並於 107 年 4 月 3 日三讀通過、總統於 107 年 4 月 25 日公布。

美國聯邦航空總署(FAA)為協調亞太地區各國對遙控無人機管理工作之一致性及增加區域內各國實務經驗交流，並以「Working Group」(工作小組)方式推動，考量我國民航法增訂遙控無人機專章修正案已經總統公布，未來制訂相關管理規亦同步與國際接軌，民航局已參加 2 次會議共同與亞太地區各國參與討論，爰持續參與亞太地區各國所組成之無人機工作小組對話平臺有利吸收其他國家實務經驗並介紹我國規定。

貳、過程

本次出國前往澳洲首都坎培拉參與「亞太地區無人機工作小組第 3 次會議會議」，會議行程自 107 年 9 月 15 日至 9 月 21 日止，會議地點在澳洲民航局會議室，除我國外，與會國家計有美國、日本、韓國、印度、印尼、新加坡、澳洲、紐西蘭及中國大陸等 10 國，各國代表共同討論無人機檢驗標準及政策方向，並做成相關決議及待確認事項。

一、行程概要：

日　期	地點	行 程 紀 要
9 月 15～9 月 16 日	臺北→雪梨→坎培拉	搭乘中華航空由臺灣桃園國際機場前往澳洲雪梨國際機場，再搭乘澳洲航空轉機前往坎培拉國際機場
9 月 17 日～9 月 20 日	澳洲民航局	出席 APAC UAS Certification Working Group 會議
9 月 21 日	坎培拉→雪梨→臺北	搭乘澳洲航空由坎培拉國際機場前往雪梨國際機場，再搭中華航空轉機回臺灣桃園國際機場

二、相關會議議程：

Day 1 – Monday, September 17, 2018	
08：30－09：00	Arrive at meeting location
09：00－09：15	Introductions and administrative announcements
09：15－09：45	Short review of previous meeting and upcoming agenda
09：45－12：00	Share assignment results on safety objective and risk classes
12：00－13：30	Lunch
13：30－16：30	Continue discussion on safety objective and risk classes
16：30－17：00	Summary of day 1
Day 2 – Tuesday, September 18, 2018	
08：30－09：00	Arrive at meeting location
09：00－12：00	Begin discussion on electric propulsion, detect and void, cyber security, and automation – including standards that each member is considering current and identification of gaps in the standards today
12：00－13：30	Lunch
13：30－16：00	Continue technology discussion
16：00－16：30	Preparation for industry day discussion (questions)
16：30－17：00	Summary of day 2

Day 3 – Wednesday, September 19, 2019	
08：30－09：00	Arrive at meeting location
09：00－12：00	Continue from TC aircraft to unmanned discussion
12：00－13：30	Lunch
13：30－14：30	Presentation and follow on discussion of FAA FAST activities
14：30－16：30	Test case run through (using a real world example)
16：30－17：00	Summary of day 3
Day 4 – Thursday, September 20, 2018	
08：30－09：00	Arrive at meeting location
09：00－12：00	Continue test case run through
12：00－13：30	Lunch
13：30－14：30	Review of items discussion and agreement on position paper towards JARUS
14：30－15：00	Proposal for next meeting (location, date and participation)
15：00－16：00	Summary of meeting

參、會議摘要

本次會議由美國聯邦航空總署(FAA)亞太地區駐新加坡代表 Ho-Joon Lim 先生邀請美國、日本、韓國、印度、印尼、新加坡、澳洲、紐西蘭、中國大陸及我國參加本(第 3)次亞太地區無人機工作小組會議，共同討論遙控無人機之檢驗標準，共有 10 國共 13 人與會。

本次會議由與會各國針對前次會議帶回研究之課題進行報告，並就無人機未來技術及檢驗等議題進行討論，其內容極具參考價值，茲將本次會議討論過程摘敘如下：

一、 第一天討論過程

新加坡代表首先說明在韓國首爾舉行第 2 次會議之摘要。並決議提交將第 2 份最終報告。美國聯邦航空局(FAA)向與會代表總結了工作小組計劃實現的一些目標及可交付成果。包括向國際民航組織 ANC-13 會議提交報告，並配合明年的國際民航組織大會舉辦時間提出更完整之報告。

與會各國針對前次會議帶回研究之課題進行報告，並且針對各國所提出對低、中、高風險無人機所要求的風險及檢驗標準之差異進行討論。

新加坡民航局分享將風險等級（Risk Classes）與相關工業標準作聯結，並供工作小組成員參考，以用來專門確定適用於無人機及 EVTOL 之低、中、高風險檢驗項目的標準。

與會各國針對前次會議帶回研究之課題，回應說明如下：

(一) 有關於 JARUS RPAS 1309 及 FAA AC 23.1309 之看法(如圖 1)。

<table>
<tr><td colspan="2"></td><td colspan="4">Classification of failure conditions</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td>Hazardous</td><td>Catastrophic</td><td>Catastrophic</td><td>Hazardous</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="4">Allowable qualitative probability</td><td colspan="2"></td></tr>
<tr><td colspan="4">JARUS – RPAS 1309</td><td colspan="4">FAA – AC for Unmanned aircraft</td></tr>
<tr><td>Classes of RPAS</td><td>Complexity Level</td><td>Extremely Remote</td><td>Extremely Improbable</td><td>Extremely Improbable</td><td>Extremely Remote</td><td>Complexity Level</td><td>Classes of Airplanes</td></tr>
<tr><td colspan="4" rowspan="2">NA</td><td>< 10^{-4}</td><td>< 10^{-3}</td><td rowspan="11">No complexity level.</td><td>UAS Risk Class 1
0 lb to 6 lb</td></tr>
<tr><td>< 10^{-5}</td><td>< 10^{-4}</td><td>UAS Risk Class 2
6 lb to 55 lb</td></tr>
<tr><td rowspan="2">RPAS-23 Class I
(SRE < 6,000 lbs)</td><td>I</td><td>< 10^{-5}</td><td>< 10^{-6}</td><td rowspan="2">< 10^{-6}</td><td rowspan="2">< 10^{-5}</td><td rowspan="2">UAS Risk Class 3
55 lb to 1,320 lb</td></tr>
<tr><td>II</td><td>< 10^{-6}</td><td>< 10^{-7}</td></tr>
<tr><td rowspan="2">RPAS-23 Class II
(MRE, STE or MTE under 6,000 lbs)</td><td>I</td><td>< 10^{-6}</td><td>< 10^{-7}</td><td rowspan="2">< 10^{-7}</td><td rowspan="2">< 10^{-6}</td><td rowspan="2">UAS Risk Class 4
1,320 lb to 3,000 lb</td></tr>
<tr><td>II</td><td>< 10^{-7}</td><td>< 10^{-8}</td></tr>
<tr><td rowspan="2">RPAS-23 Class III
(SRE, MRE, STE or MTE > 6,000 lbs)</td><td>I</td><td>< 10^{-7}</td><td>< 10^{-8}</td><td rowspan="2">< 10^{-8}</td><td rowspan="2">< 10^{-7}</td><td rowspan="2">UAS Risk Class 5
3,000 lb to 12,500 lb</td></tr>
<tr><td>II</td><td>< 10^{-7}</td><td>< 10^{-9}</td></tr>
<tr><td>RPAS-23 Class IV</td><td>NA</td><td colspan="2">Refer to AC 23.1309-E</td><td>< 10^{-9}</td><td>< 10^{-8}</td><td>UAS Risk Class 6
Above 12,500 lb</td></tr>
<tr><td>RPAS-25</td><td>NA</td><td colspan="2">Refer to AMC 25.1309</td><td colspan="2">Refer to AMC 25.1309</td><td>Part 25</td></tr>
<tr><td>RPAS-29</td><td>NA</td><td colspan="2">Refer to AMC 29.1309</td><td colspan="2">Refer to AMC 29.1309</td><td>Part 29</td></tr>
</table>

圖 1 JARUS RPAS 1309 及 FAA AC 23.1309

1. 新加坡：

(1) 在某種程度上，各種風險等級和無人機系統重量等級的原則是相同的，即確定無人機之最大可能速度，並因此確定無人機碰撞時所產生的影響。不同之處在於，引入新技術時是否需要更高級別的災難性程度要被考慮。從最終效果的角度來看，無人機撞擊地面所造成的破壞與同類型的有人機造成的破壞相似。因此從技術上來說，新技術的引入不應該導致認證過程中災難性程度的增加，除非該技術是全新的技術，其中無人機能夠獨立決定如何做出反應。也就是說，新技術的操作方式可能需要額外的保障措施，這最終將為提供更高程度的保證。基於上述考慮，FAA 提出的災難性程度的系統設計目標似乎是合理的。

(2) 不認為有必要單獨定義復雜程度，但需要確定認證的界線，即排除人工智慧，直到有更好的理解和共識。在回顧不同的複雜程度

時，複雜等級(Complexity Level)1 似乎與當今有人機中的現有技術相似，其中電子硬體在飛行員的監督下自動執行某些功能。如果現有載人飛機不需要這些功能的複雜等級，則對於無人機應該是相同的。至於複雜等級 2 或 3，它涉及人工智慧的界線，在這個時刻我們可能無法充分理解。

2. 中國大陸：

(1) 風險等級(Risk Class) RC 3 至 6 的安全目標似乎合理。對於 RC 1 和 2，可能存在無害的操作，例如農業服務。所以相關的規定可能過於嚴格。

(2) 無論系統多麼複雜，無人機碰撞的最終結果都與無人機的動能有關。更複雜的系統不會增加無人機的危害。 因此，無需通過向無人機設計導入複雜系統來增加安全目標。

(3) 此外，增加的安全目標可能會阻止將創新技術導入無人機設計並且降低安全水平。

3. 紐西蘭：

(1) 在極端情況下，對於在偏遠地區 400 英尺以下操作 6.5 磅重的無人機來說，10^{-5} 似乎很艱難。然而，基本假設是這些低風險操作不需要 TC，因此不能依據 AC 23.1309 來設計。對於高風險操作（例如飛越密集人群，超過 400 英尺視距外），確實需要 TC 或 TSO，那麼這些數字似乎是合理的。

(2) JARUS 提出了增加無人機安全目標和設計保證水平的理由，因為與同等類型的有人駕駛航空器相比，由於依賴更多複雜的系統來降低潛在危險。紐西蘭不同意，原因有三：

- 在沒有增加安全目標的情況下，將有復雜系統導入有人駕駛航空器的優先權，例如：第 23 部分飛機中的集成玻璃駕駛艙，第 27 部分飛機中的電傳操縱系統。

- 增加的安全目標可能是障礙，實際上是增加了複雜性、重量、成本和任務功能。

- 雖然無人機通常要求的功能代表更高的安全水平，但它們仍然只是功能，安全目標應與安全結果直接相關聯。在小型無人機的情況下，由於機上沒有人和較低的動能，造成的傷害結果通常較小。因此，增加安全目標是不合理的。

4. 美國：

(1) 美國設定了提議的目標系統安全值，並認為它們代表了不同類別無人機的合理安全目標，依據美國提出的基於動能和操作風險分類模式進行分類。這假定了"操作"安全目標來自飛機系統開發的系統及安全目標與設計特性、操作限制、空域限制和其他方面的結合。

(2) 基於複雜性對其他安全目標進行分類，假設我們都可以就技術來證明這一術語的定義。什麼是複雜，就是每天隨著技術、認證政策和運營經驗而發展。隨著航空業和認證機構對特定技術的熟悉和信心，技術經常從複雜演變為世俗。

(3) 提高複雜系統的安全水平也會造成意外後果，即可能來自新技術的安全增加而產生壓力。

5. 韓國：系統設計目標似乎沒有解決飛行或地勤人員所產生的影響。類似於先前的說明，鼓勵增加運營安全的方式，例如飛行員加以培訓等。

(二)無人機之監管強度等級(如圖 2)。

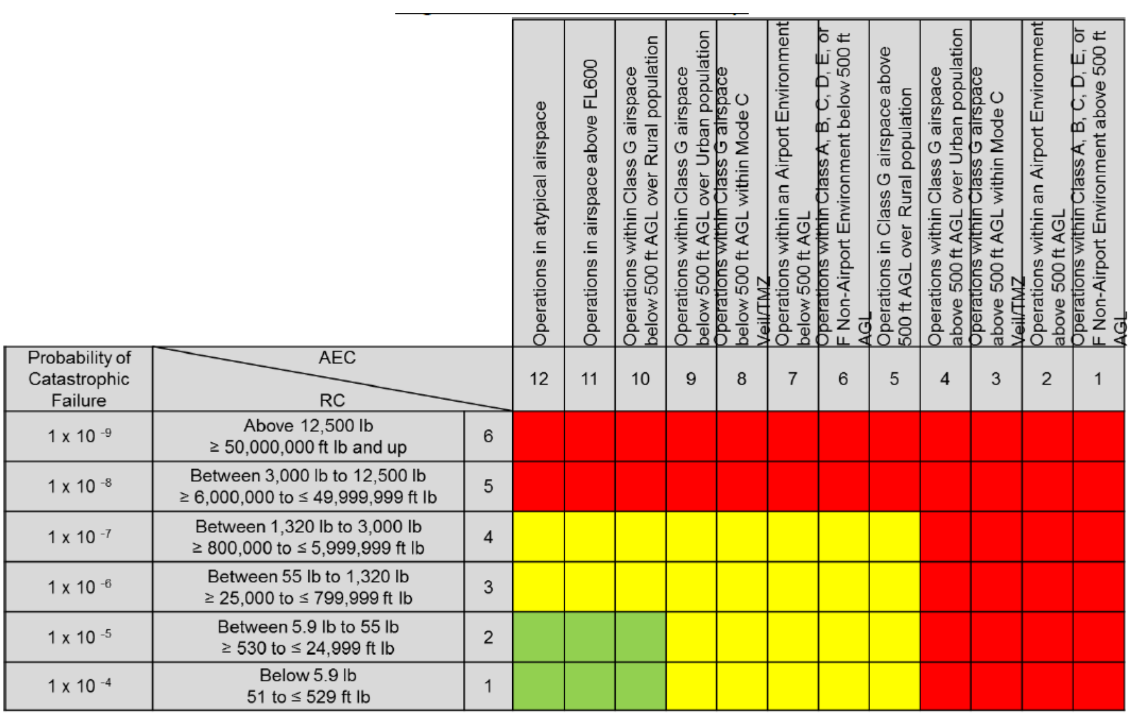


圖 2 RC VS SEC MAP

1. 新加坡：

(1) 新加坡空域類別分針對無人機分成以下 4 類不須要型別檢定(Type Certificate)：飛行在 1 公里範圍內的操作、機場 5 公里範圍內的操作、距離機場 5 公里以外且 200 英尺以上的操作、距離機場 5 公里以外且 200 英尺以下的操作。

(2) 對於在紅色區域的不分，需要參考國際民航組織的規定，因為紅色區域的無人機產品很可能用於國際業務。對於在黃色區域的不分，需要在本工作小組範圍內進一步討論，因為需要進一步開發當地監管架構。對於產品在綠色區域的不分，目前已經在沒有任何形式的雙邊協議。但是，展望未來，各國就行業可以選擇遵守的一套標準達成一致將是有益的。

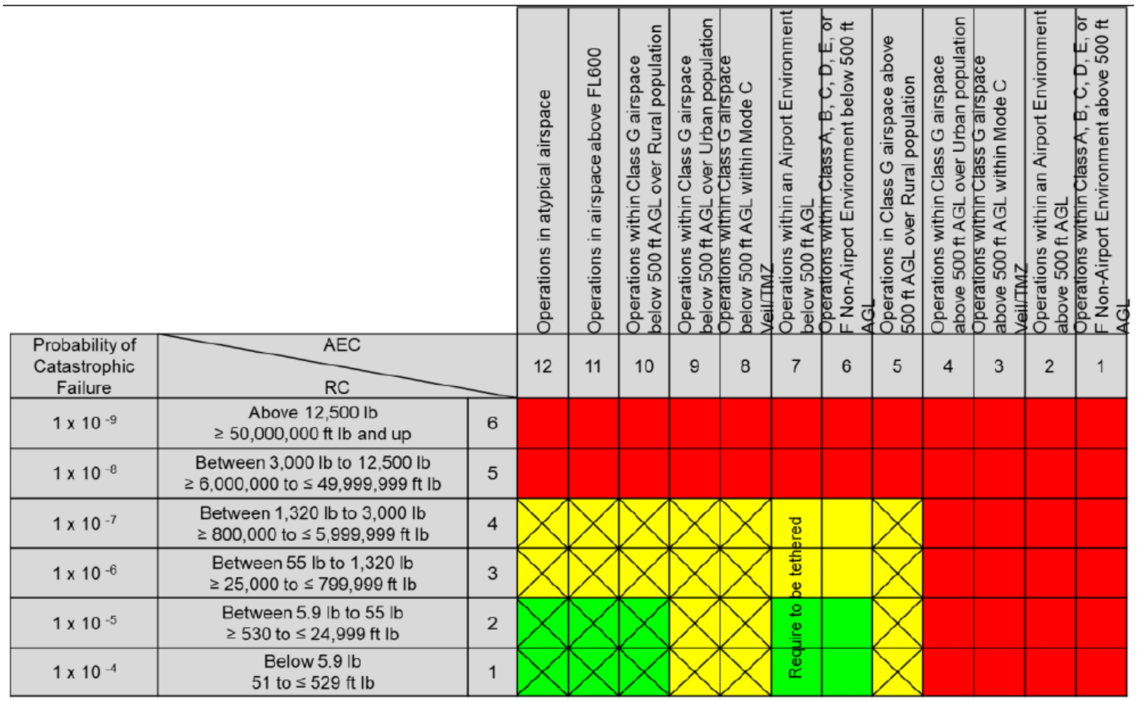


圖 3 新加坡監管強度等級表

2. 中國大陸：

(1) 中國的空域分類與 Airspace Encounter Categories (AEC)完全不同。目前分類方法正在製定中。且希望能夠就機制達成一致性，避免造成其他申請人額外的負擔。主要的挑戰是兩個國家間所設定的的差異，因此雙方應就此問題達成協議。

(2) 對於案例 1 和案例 2，將適用行業標準；對於案例 4，證書基礎可能包含適用的行業標準和第 23/27 部分的適用要求。(如圖 4)

3. 紐西蘭：

(1) 所有 AEC 空域類別與紐西蘭相同。

(2) 綠色區域：無生產標準。黃色區域：規劃以 AS/EN9100 或可能較低的 ISO9001 要求將成為通用標準。紅色區域：須要生產認證（紐西蘭第 148 部製造機構證書）

Probability of Catastrophic Failure	AEC / RC		Operations in atypical airspace	Operations in airspace above FL600	Operations within Class G airspace below 500 ft AGL over Rural population	Operations within Class G airspace below 500 ft AGL over Urban population	Operations within Class G airspace below 500 ft AGL within Mode C Veil/TMZ	Operations within an Airport Environment below 500 ft AGL	Operations within Class A, B, C, D, E, or F Non-Airport Environment below 500 ft AGL	Operations in Class G airspace above 500 ft AGL over Rural population	Operations within Class G airspace above 500 ft AGL over Urban population	Operations within Class G airspace above 500 ft AGL within Mode C Veil/TMZ	Operations within an Airport Environment above 500 ft AGL	Operations within Class A, B, C, D, E, or F Non-Airport Environment above 500 ft AGL
			12	11	10	9	8	7	6	5	4	3	2	1
1×10^{-9}	Above 12,500 lb ≥ 50,000,000 ft lb and up	6												
1×10^{-8}	Between 3,000 lb to 12,500 lb ≥ 6,000,000 to ≤ 49,999,999 ft lb	5												
1×10^{-7}	Between 1,320 lb to 3,000 lb ≥ 800,000 to ≤ 5,999,999 ft lb	4												
1×10^{-6}	Between 55 lb to 1,320 lb ≥ 25,000 to ≤ 799,999 ft lb	3			1	3		2					4	
1×10^{-5}	Between 5.9 lb to 55 lb ≥ 530 to ≤ 24,999 ft lb	2												
1×10^{-4}	Below 5.9 lb 51 to ≤ 529 ft lb	1												

圖 4 中國大陸監管強度等級表

4. 美國：

(1) 如圖 5 所示，略微調整了低風險空域中的飛機，我們可能不需要對這些類型的操作/運用進行設計。除了最嚴格的環境之外，我們還設想風險等級 1 在沒有 TC 的情況下操作。這是因為需要在無人居住的地區容納在高海拔地區運行的大型無人機系統，或在海上進行長距離貨物作業，因為地面風險和空氣風險具有固有的中等風險。

(2) 美國將使用類似 SORA 的流程對黃色區域進行初步分類，以確定飛行員及維護之水平。這些項目也將在第 21 部的修正案中得到解決，並會稱作現代化的特殊適航驗證(Modernization of Special Airworthiness Certification, MOSAIC)。

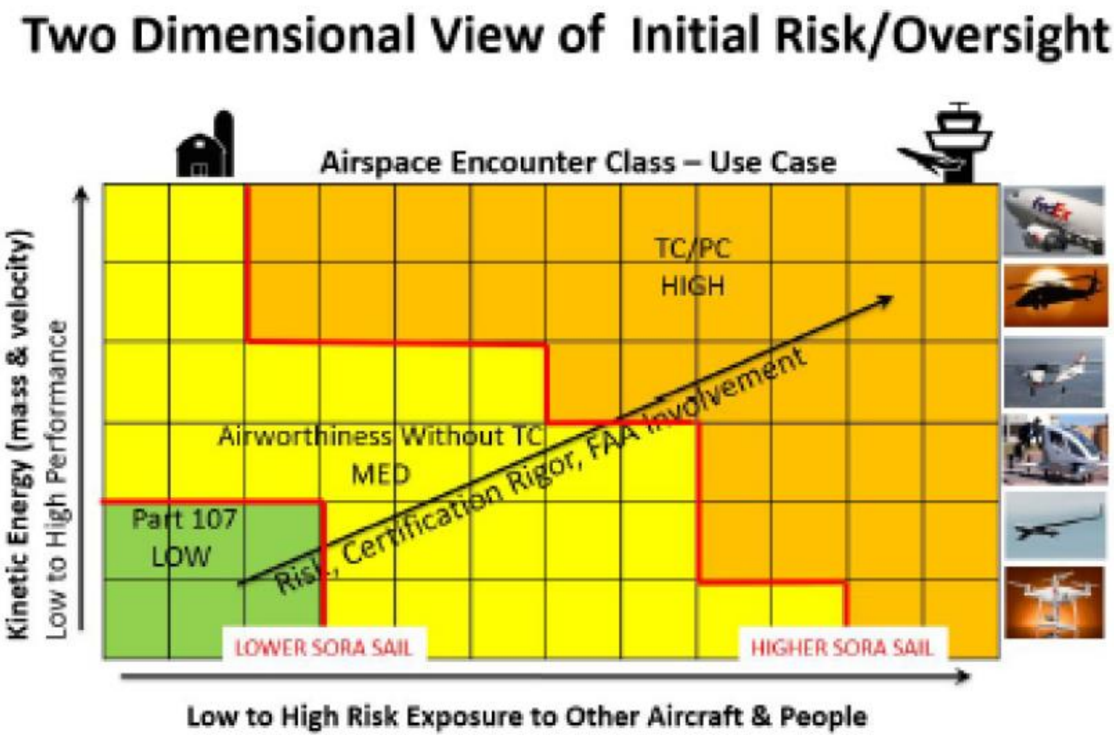


圖 5 美國風險評估表

5. 日本：低於 55 磅(25 公斤)的無人機，查覺到市場正在創造各種創新，並且目前正處於技術過渡期，不應現在決定 55 磅(或更低)的設計標準。因此，現在 JARUS 的標準是正確的。圖 6 為技術過渡期的證明數值

Failure			(/h)	Accident rate	
Equipment failure	Communication system (communication disabled)		10^-2	3x10^-2 (MTBF=33.6 h) Reliability 97.028833	2x10^-1 Reliability 83.876562
	Propulsion system (malfunction of motor driver)		10^-2		
	Power system (malfunction of voltage monitoring function)		10^-2		
	Control system	Acceleration & angular velocity sensor malfunction	10^-5		
		Software malfunction	10^-6		
Environment	Gust		10^-2		
	Geomagnetism distortion		10^-2		
	Electromagnetic interference		10^-4		
Human error	Setting error		10^-1		
	Misoperation		10^-2		
Avoidance of harm	Recognize aircraft approaching at high speed, possibility that people can not avoid		10^-2		
	Possibility of touching propeller guard		10^-7		

圖 6 日本無人機事件比例植

6. 韓國：目前超過 150 公斤的無人機必須取得 TC 證書。

7. 我國：使用不同的 AEC，如圖。可能需要製定轉換表以確定需要使用雙邊協議的內容以及不需要的內容。

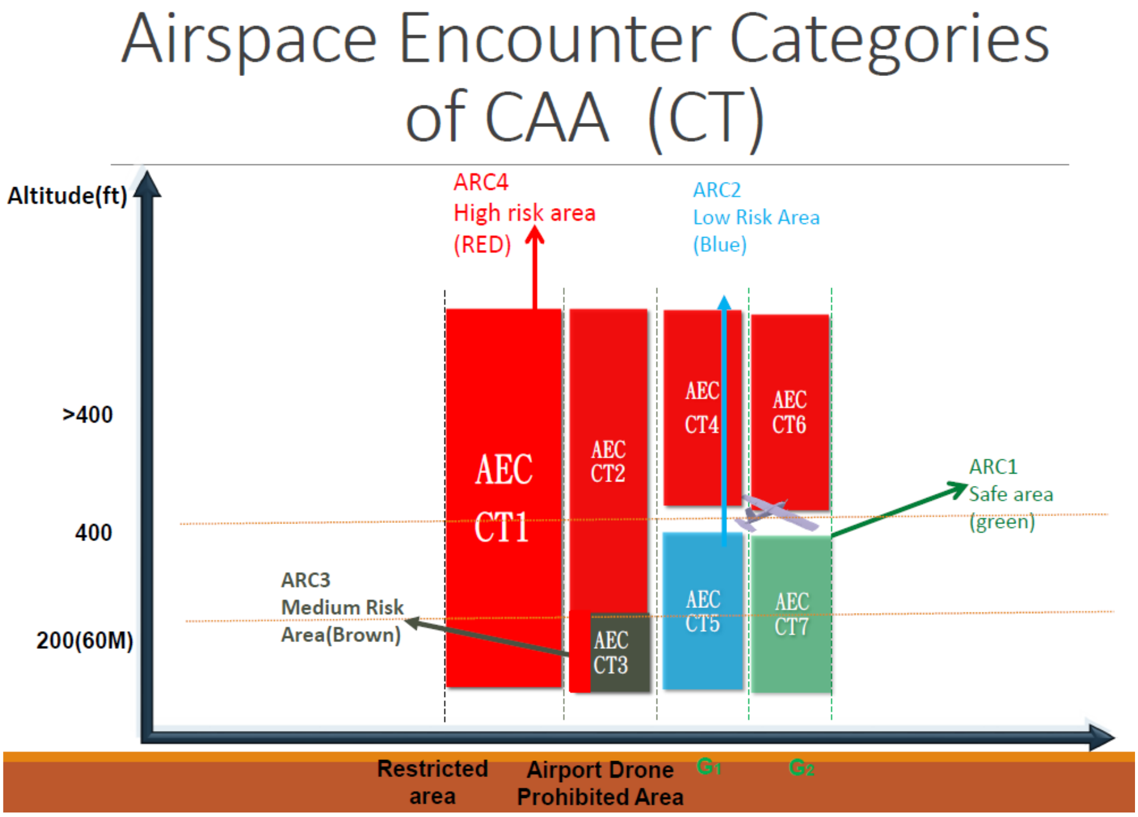


圖 7 我國 AEC 分類

(三)將已獲得型式檢驗(Type Certificate)之有人機改裝為無人駕駛之看法。

1. 新加坡：

(1) 雖然沒有規定阻止 CAAS 頒發補充型式證書，將有人駕駛飛機轉換為無人駕駛飛機，但該政策還需要進一步審議。國際民航組織採取的方法是針對所有在國際上運行並依據儀器飛行的無人機作為型式檢驗。型式檢驗證書的定義也將修改為“締約國為確定飛機，遠程駕駛員，發動機或螺旋槳類型的設計而證明該設計符合該國適當的適航要求的文件”。

(2) 持續適航方面，誰將負責管理改裝飛機的持續適航性？是 TC 持有人還是 STC 持有人？既然會有額外的遠程駕駛站，以前發布的適航證書是否仍然有效？基於 TC 發布的適航證可能無效。

2. 中國大陸：

(1) 依據 AC21.19，有人機改裝為無人駕駛航空器必須重新申請新的型式檢驗。

(2) 原始的 TC 持有人可能無法將有人駕駛航空器轉換為無人駕駛航空器，因此這類 TC 的轉換可不限定於原有 TC 的持有人申請。

3. 紐西蘭：

(1) 雖然通過對 AC 21.101 的嚴格定義，變更需要新的型式證書，但飛機的實際物理變化大多是低影響的，並且有人駕駛航空器的許多認證工作仍然適用。 STC 是可以接受的，因為它有幾個優點，STC 持有者可能更熟練地設計無人機系統，紐西蘭民航局設想使用無人機系統的共同經驗和知識轉換有人駕駛航空器的專業 STC 持有者。由於將可能是重大的變更，STC 過程仍然需要將系統更改為最新修正的版本。 STC 持有人需要評估原始 TC 設計，以確保其仍然適用。

(2) 將改裝後的飛機納入空域可能會帶來與新的無人機設計不同的挑戰，因為它們可能仍然依賴於非無人機系統設計的基礎設施(如跑道等)。

4. 美國：新的 TC 申請人/持有人必須能夠獲得所有原始設計數據，因此 OEM/ TC 持有人可能無法完成，必需依據原始證書之限制來衡量，以避免安全問題。 無人駕駛自動化必須將飛機保持在其最初認證的範圍內，或者顯示任何變化的適用性，自主化還需要保護飛機的原始結構、速度及操作範圍。

5. 日本：有人駕駛航空器改裝為無人駕駛，不僅要更換或額外安裝重要設備以確保安全，而且還包括被改裝飛機(原有 TC 飛機)對系統之間的，特別是導航系統、飛行控制系統，很可能會顯著影響適航性，它被認為是由 TC 持有人或同級飛機製造商執行的內容。

6. 韓國

7. 我國

第 1 天總結，雖然在第一次會議上同意各國自行規範 25kg 以下無人機之規範，但在這些級別(RC1 及 2)中有不同的定義、應用和應用內容。例如，可能存在即使在 RC 1 及 2 也需要 TC 或某些許可下才可從事活動的情況。此外，在人口密度不同的情況下，安全目標值為多少？。在風險分類中，各國對紅色區域的看法完全一致(除了美國認為在 AEC 11 和 12 中操作的 RC 5 和 6，無人機需要進行型式驗證)。綠色和黃色區域各國間仍存在差異，需要進一步討論。

二、 第二天討論過程

與 ASTM F38 主席和 RTCA SC 228 的美國代表進行視訊會議，討論無人機標準的最新進展。ASTM F38 力主小型無人機在低空的各種航務、適航標準；RTCA SC288 則專注高高度大型無人機的 C2 LINK 與 DAA 標準。ASTM 是一個全球工業標準組織，其成員遍布全球。相關簡報如附件。

RTCA SC-228 分為兩個工作組，檢測和避免(Detect and Avoid, DAA)和命令與控制(Command and Control, C2)。RTCA 完成了 SC-228 第 1 階段的可交付成果，目前正在進行第 2 階段工作。在第 1 階段沒有考慮地面雷達效應，但在第 2 階段正在進行研究。在 2018 年 6 月，第一次使用系統開發的 FAA TSO 識別 SC-228 的可交付成果。美國航空暨太空總署在一般空域上執行了 Ikhana 無人機的試飛。這次飛行是第一次使用機載檢測及避免(DAA)技術來滿足美國聯邦航空局「看到和避免」的規定。

(一)技術討論

日本民航局介紹了當前的研發主題並展示了無人機在福島縣的測試空域，包括飛行汽車。目標是在 2020 年奧運會上推出新的無人機管理系統，計劃於 2025 年交付。

(二)註冊討論

澳洲及我國希望將 ASTM Remote ID 整合到註冊系統中。而紐西蘭目前尚未有所規劃。美國正研究使用當前的註冊方式並使其與 Remote ID 相容。

(三)電力系統討論

美國分享了一個實驗性質測試的成功案例「Pipistrel Alpha Electro」，並且可藉由一位非訓練有素或超輕載具的飛行員操作。

美國聯邦航空局與航空暨太空總署分享了 X-57 的合作案。目的是收集有關電池安全性、電機設計、電機控制器設計和該飛機操作安全性的經驗，以便記錄電動飛機的基本設計、性能和操作標準。

(四)自動駕駛

美國聯邦航空局考慮使用較低的技術水平來建立自動駕駛功能，從較低風險的小型無人機系統開始，未來擴大至較高風險的大型無人機上。並且針對「自主性」(Autonomous)一詞作定義。ASTM AC 377 正致力於自動化的通用術語及分類。我們可以與小組分享這些條款。

美國聯邦航空局分享了有關美國航空暨太空總署的一些資訊。其目的是幫助所有公司可以遵循的測試標準、動作和模擬操作，在這些測試範圍內，新設計的無人機可以比直接進入城市(人口稠密區)，且更安全地進行測試。

紐西蘭分享了 Zephyer 載客無人機的安全計畫。

三、 第三天討論過程

美國聯邦航空局未來飛機安全小組(Future Aircraft Safety Team, FAST)正在思考聯邦航空法第 23 部不足的地方，以便能夠處理有人駕駛的固定翼城市空中載具(Urban Air Mobility, UAM)，可水平飛行同時也可以垂直飛行的推進系統，並且能夠在關鍵的動力或推力故障之後安全地飛離或著陸。

美國很早就發現聯邦航空法第 23 部的改變是否導致特殊條件的減少，但總是少了某些特殊條件。早期參與的業者和美國 FAA 正準備和處理具有非傳統技術來符合法規的程序。

申請人是否採用美國聯邦航空法第 21.17(a)或(b)的認證途徑應該是沒有任何的不同。由於這些型式的項目在早期已參與和擴展，因此 3 年的限制也不會造成任何的困擾。(如圖 8)

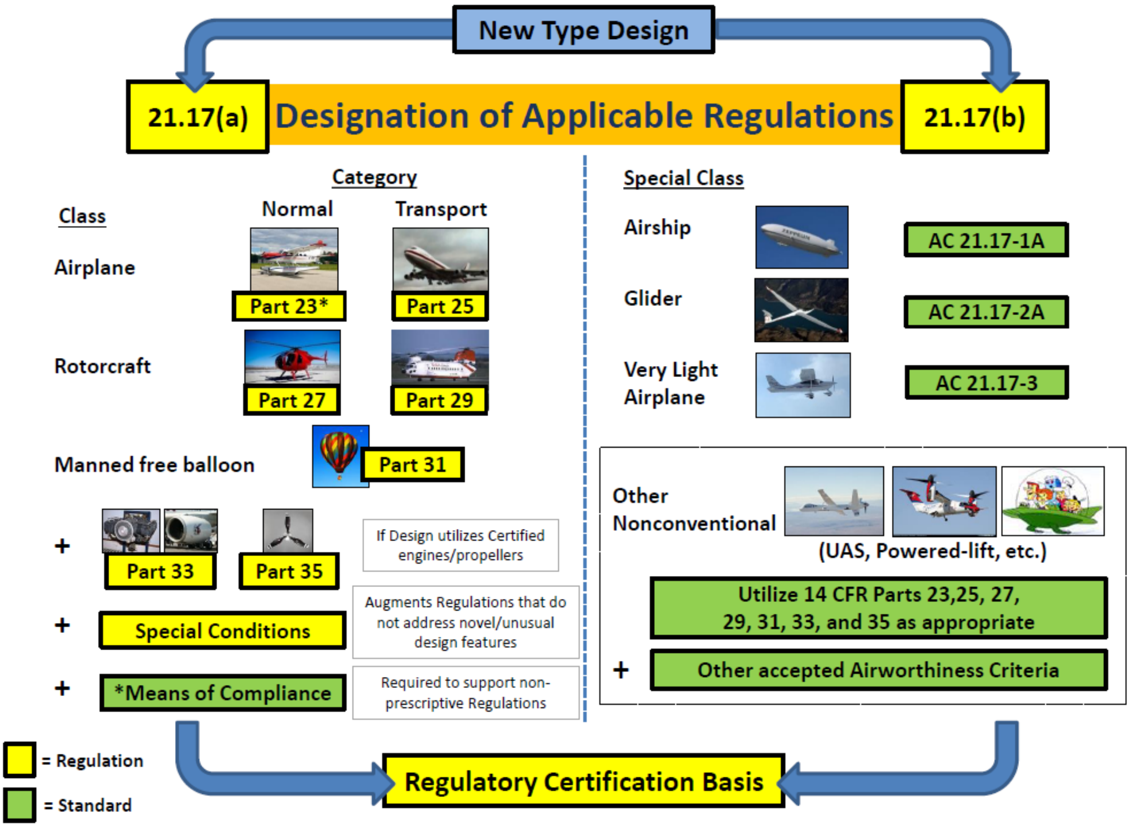


圖 8 美國聯邦航空法第 21.17(a)或(b)比較

國際合作的夥伴都有不同程度的專業知識。假如使用工業標準，這些產品出口時可能會產生意想不到的後果。無人機未來的 TCDS 將不再列出認證的基礎項目，進而衍生改裝或修改時的困難之處。

<u>紐西蘭實際案例檢視</u>

如果使用美國聯邦航空法第 21.17(b)是不需要有特殊條件的。在 FAST 討論之後，看起來第 23 部及第 27 部的規定，大部分可以與相關的工業標準一起使用以滿足要求。

在這個測試案例中，美國 FAA 可能提出第 23 部分和第 21.17(a)的檢驗路徑，因為 VTOL 是唯一的非傳統方法。

eHang 和豐田"飛行汽車"現階段還無法分享將使用哪種方式進行檢驗。飛行車最有可能使用第 21.17(b)的規定，這取決於它是以固定翼方式巡航，還是由旋翼片提供升力。

有些情況是有人在機上駕駛轉換為無人在機上駕駛的情況。從有人駕駛到無人駕駛的自動化過程將會允許融入現有的空域內，即使它造成自動駕駛的設計更加複雜化。

<u>參觀 Project Wing</u>

至 Project Wing 貨運測試場參訪。該場域位於崁培拉西側，目前約有 150 餘名訂戶在使用，每天平均大約運送 50 件包裹(咖啡餐點)。

<u>實際案例檢視(Project Wing)</u>

Project Wing 所使用的無人機重量約 5.5 公斤，最大籌載為 1.2 公斤。

澳洲民航局在 2014 年同意了 Project Wing 的測試場域。主要在隔離空域的基礎上進行測試運營，並與當地 EMS 運營商達成協議，如果他們需要啟動接收病人，則稱其為「巢」(NEST)和地面翼營運商(Ground Wing Operations)。

目前大約有 4,200 個航班，自 2018 年 5 月以來共有 17,000 個航班。

Project Wing 似乎適合列入 Risk Class 2 和 Air Encounter Class 9 的評估項次中。雖然執行任務時確實進入了一些人口密集區域，但是飛行路徑的主要部分還是在遠程或非擁擠區域進行。

第 3 天總結，FAST 分享的資訊將幫助各國進一步了解美國 FAA 對無人機型式檢驗的方法。關於美國聯邦航空法第 14 部的討論，各國仍必須進一步檢視該方法是否可用於驗證此類飛機的型式。另外提高操作風險以及從低風險到高風險所需的步驟，惟這需要再更進一步討論。

四、 第四天討論過程

工作小組將考慮將核准程序寫進報告內，例如首先確認等級位於綠色、黃色、紅色區域內，然後使用 SORA 找出需要降低的風險的項目來評估降低風險等等。

美國 FAA 目前正在研究黃色區域內的無人機進行簡單的型式檢驗，因為目前 FAA 已被授權為適用於黃色區域的飛機核發型式檢驗證書。

ASTM 目前沒有列出任何安全級別用於其標準中的可靠性，但 FAA 將在未來的指導文件中發布。

工作小組並決定了各國回去研究的課題，包括決定無人機各項工業標準、UAS TCDS 格式內容等，並於下次會議中討論。

五、 本次會議重點整理

第一天討論重點內容如下：

(一) 澳洲 CASA 的 RPAS 辦公室約有 20 餘人力，負責 RPAS 各項推動事宜並積極參與 ICAO RPAS PANEL、JARSUS 等國際無人機標準組織。此次 APAC UCWG 會議亦為 CASA 第一次參與。

(二) 第一天議程針對下列議題進行討論：

1. FAA 和 JARSUS 的 Risk Classification(RC)
2. 各國空域 Level of Rigor and Oversight Mapping
3. UAS 改裝後，以 STC 取得適航之可能性
4. 各國對無人機之電力推動、自動化、網路安全及偵測與避讓等意見

(三) 印尼 DGCA 的一位適航檢查員及一位航務檢查員作為觀察員參加會議。

(四) 另一名觀察員印度民航局表示，該國無人機法規 CAR 3 將於 12 月 1 日生效。

(五) 明日上午 9 時，將與美國 ASTM F38 主席進行電話會議討論無人機偵測、C2 Link 等議題。--- 與 RTCACS 228 的無人機標準比較。

第二天討論重點內容如下：

(一) 與 ASTM F38 主席和 RTCA SC 228 的 FAA 代表進行視訊會議，討論無人機標準的最新進展。ASTM F38 力主小型無人機在低空的各種航務、適航標準；RTCA SC288 則專注高高度大型無人機的 C2LINK 與 DAA 標準。

(二) 由我國、日本及印度民航局對該國新法規進行細節說明。

(三) 討論無人機的電力推進、人工智慧與自動化、網路安全等議題。我國代表於議題中提出 NASA 和 FAA 合作計畫中，如何以 NASA TRL 衡量無人機自動化技術成熟度。

(四) 紐西蘭展示該國 Zephyer 載客無人機的安全計畫考量。

第三天討論重點內容如下：

(一)與 FAA FAST Future Aircraft System Team 討論最近有關電力推進飛機、載人空中飛車等申請案之檢定基礎及 FAA 如何藉由最新版的 Part 21.17(b), Part 23 Amd 64 去調和工業標準，甚至 Part 27 的內容，以處理複合式航空器的問題。

(二)至 Google Wing 貨運測試場參訪。該場域位於崁培拉西側，目前約有 150 餘名訂戶在使用，平均大約運送 50 件包裹(咖啡餐點)。

(三)以 Google Wing 為例討論其風險程度與相關適航考量。

(四)新加坡代表展示新加坡大學(NSU)校區內的 Airbus 無人機送貨實驗。

第四天討論重點內容如下：

(一)討論本次會議最重要主題「Operational Safety Target and System Safety Target」，部分與會代表如我國、印尼及韓國表達這兩者的區分在 airworthiness 中並未清楚定義。

(二)決定下次題目。其內容包括決定無人機各項工業標準、UAS TCDS 格式內容、各色區域標準設定等。

(三)與日本 JCAB 代表約定未來台日雙邊無人機交流事宜。

(四)決定下次會議是明(109)年 3 月，地點為美國。

伍、心得與建議

本次參加第 3 次亞太地區無人機工作小組會議之心得及建議如下：

一、 持續與工作小組成員協同合作

近年來無人機已從成本高的軍事用途逐漸的轉型為成本低廉的娛樂或商業用途。我國並於 107 年 4 月通過民用航空法增訂遙控無人機專章修正案，惟相關之檢驗標準世界各國仍未有統一之作法，參加工作小組會議除可吸取他國經驗，並可與各國主管機關共同商討國際間之標準，拓展我國在國際間之能見度，對於第一時間取得最新資訊亦有所助益。未來仍將持續與工作小組成員保持密切聯繫合作，以維持與國際接軌及國內無人機相關規範之一致性，提升遙控無人機飛航活動之安全。

二、 掌握國際間之標準並適時調整我國規範

近年來遙控無人機技術發展迅速，惟國際間係各自訂定規範，尚無統一之標準。本局雖自 100 年起發布航空公報(AIC)，受理國防、公務及以政府經費實施研究之遙控無人機作業之申請，但對於一般民間團體卻無專法管理。為提升遙控無人機之活動安全及保障有人航空器之飛航安全，本局自 104 年起推動修正「民用航空法」增訂遙控無人機專章以規範管理遙控無人機，並於 107 年 4 月 25 日由總統公布，規劃一年後施行，雖本局以委請國家中山科學研究院針對遙控無人機檢驗標準進行研究，積極參與國際間之會議或交流可吸取經驗、廣泛蒐集各類相關資訊，並適時調整我國規範。

附件 一、ASTM 簡報

What is ASTM?

A Proven and Practical System

- Established in 1898
- 150 Committees & 12,500+ Standards
- 32,000 members
  - 8,000+ International Members from 149 countries
  - 7,100 ASTM standards used in 80 countries
- Process complies with WTO principles: Annex 4 of WTO/TBT Agreement

Industry comes Together

- Experts, individuals, organizations, academia, regulators, trade associations, consultants and consumers
  - Exchange expertise and knowledge
  - Participating in a transparent process – open to anyone, anywhere

Industry driven, Global, Market relevant, No project costs

ASTM's Membership Globally

Offices In:
W. Conshohocken, PA (USA – HQ)
Beijing, China
Brussels, Belgium
Lima, Peru
Ottawa, Canada
Washington, DC

ASTM/MOU

ASTM International's Memorandum of Understanding (MOU) program supports the principles of the World Trade Organizations' Technical Barriers to Trade Agreement.

ASTM has memoranda of understanding with 98 National standards bodies around the globe

- Both ASTM Members and MOU Partners
- ASTM MOU Partners Only
- ASTM Members Only

July 2017

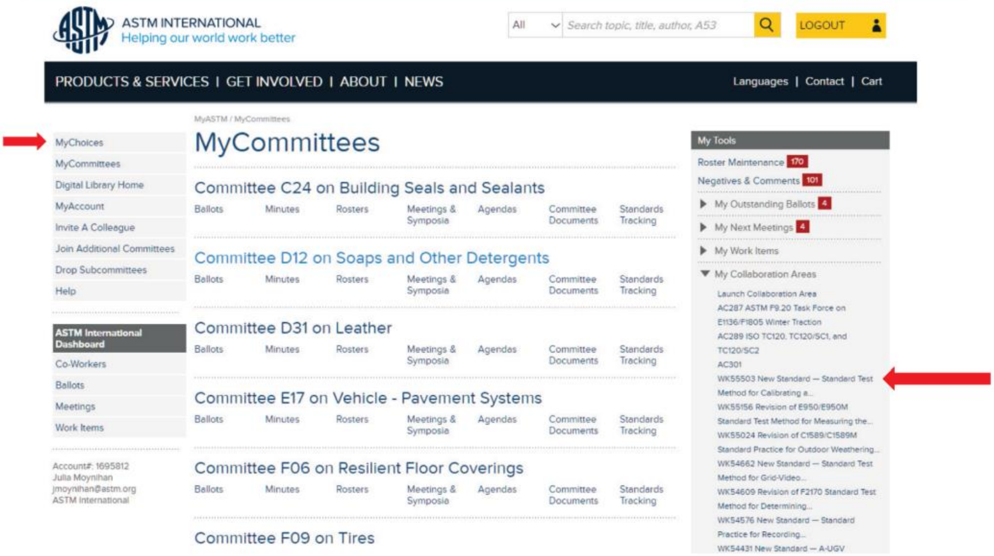
ASTM Collaboration Area

Collaboration area features include:

1. A central location for draft documents
   - Add comments, start a new discussion
2. File repository
   - Add related files, images, tables, etc.
3. Task group member list
   - Easily send email to individuals or entire task group
4. History
   - See actions taken over the life of the collaboration area

- Collaboration area can be established as part of the work item registration process or at a later date

My Collaboration Areas



Aerospace Sector – Comprehensive Standards Development

Standards Developing Committees

F37 Light Sport Aircraft
- Standards: 35 approved; 4 in development
- FAA NOA's

F38 Unmanned Aircraft Systems
- Standards: 14 approved; 10 in development
- New rule recently published; FAA acceptance via AC's

F39 Aircraft Systems
- Standards: 6 approved; 9 in development
- FAA Notices

F44 General Aviation Aircraft
- Standards: 29 approved; 10 in development
- New rule recently published; FAA acceptance via AC's

F46 Aerospace Personnel
- Standards: 1 approved, 7 in development
- Formed December 2014, not for regulatory means

F47 Commercial Spaceflight
- Officially formed October 2016
- Approved by Board December 2016
- Supports COMSTAC recommendations
- Following LSA model
- Standards: 12 in development

Training and Certification

NCATT Testing & Certification
- Aircraft Electronics Technicians (AET)
- AeroIT
- Foreign Object Debris
- many more…

LSA Personnel Certificate Program
- Training for compliance personnel

– B07 on Light Metals and Alloys
– D02 on Petroleum Products, Liquid Fuels and Lubricants
– D30.09 on Sandwich Constructions
– E07 on Nondestructive Testing
– E17 on Vehicle-Pavement Systems
– F07 on Aerospace and Aircraft
– F34.06 on Aerospace

F38 Unmanned Aircraft Systems

Quick facts:

Formed: 2003, memorandum agreement with FAA
Current Membership: 230+ members (30 regulators)
Standards: 15 approved; 25+ in development

Subcommittees:

F38.01 Airworthiness
- Hardware oriented
- Safe design, construction, test, modification, & inspection of the individual component, aircraft, or system

F38.02 Flight Operations
- Procedure oriented
- Safe employment of the system within the aviation environment among other aircraft & systems

F38.03 Personnel
- Individual, Crew and Organization Oriented
- Safe practices by the individuals and teams responsible for employing the system

Global Representation
Argentina
Australia
Bahamas
Canada
China
France
Germany
Italy
Korea, Republic of
Netherlands
New Zealand
Norway
United Kingdom
United States

Also Require Infrastructure capable of incorporating this technology safely in the NAS- ATM,UTM, LAANC

 7

ASTM UAS Industry Consensus Standards-Value Proposition

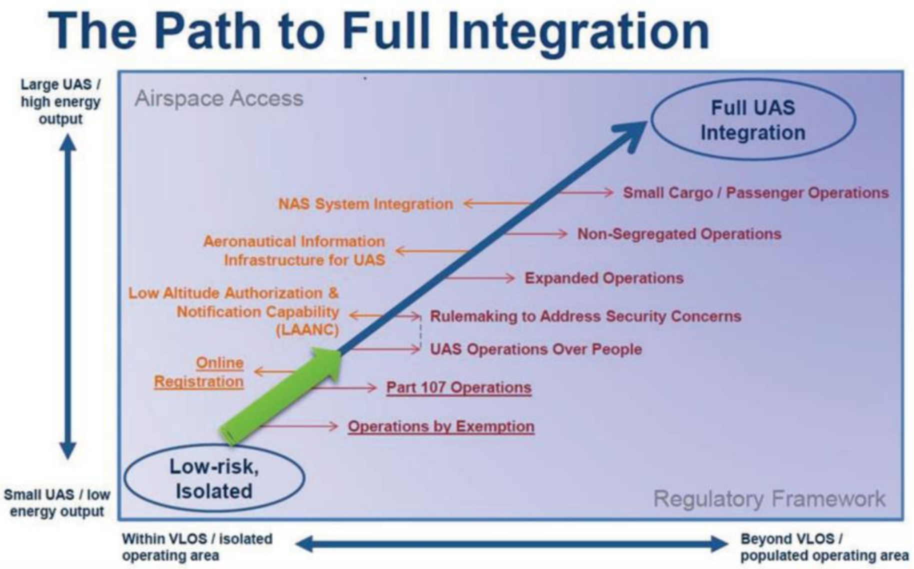
Industry links the most current research & sets the requirements for new and novel technology to support rulemaking

- Enhances knowledge of the regulating authority on a particular technical subject
- Ensures the standards reflect the most current technology and research rather than dated information
- ASTM International as one central point of international participation from authorities and industry would greatly improve the effectivity and global applicability of the standards.

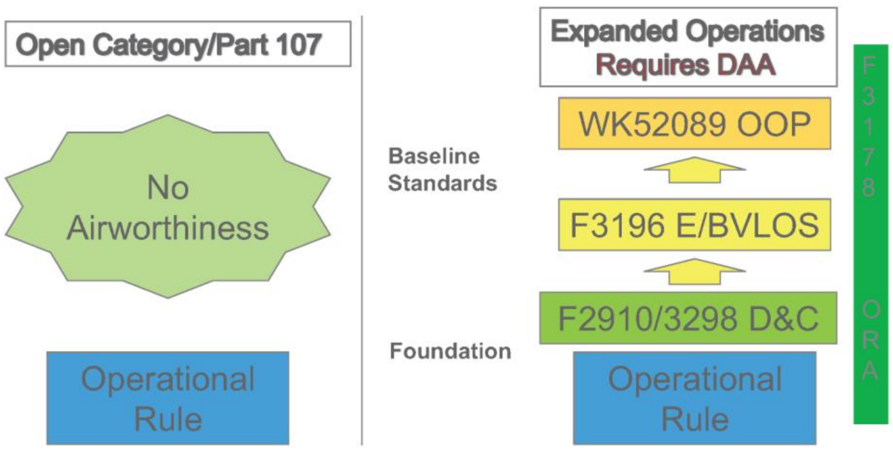
Industry Benefits

- Ensure Safety, Reliability & Quality
- Facilitate Free & Fair Global Trade-acceptance
- Spur innovation / drive business growth
- Enable interoperability of products, processes, systems
- Lower research and development costs
- Promote quality and efficiency in supply chains
- Reduce liability and regulatory compliance risks

F38 Goal : Industry Standards Achieving Safe & Reliable UAS Operations



Next Steps Expanded Operations : Integration not Segregation



ASTM F38 Published Standards

F2849-10 Standard Practice for Handling of Unmanned Aircraft Systems at Divert Airfields

F2851-10(2018) Standard Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)

F2908-16 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)

F2909-14 Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)

F2910-14 Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)

F2911-14e1 Standard Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS)

F3002-14a Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)

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ASTM F38 Published Standards

F3003-14 Standard Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

F3005-14a Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

F3178-16 Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)

F3196-17 Standard Practice for Seeking Approval for Extended Visual Line of Sight (EVLOS) or Beyond Visual Line of Sight (BVLOS) Small Unmanned Aircraft System (sUAS) Operations

F3201-16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)

F3266-18 Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement

F3269-17 Standard Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions

F3298-18 Standard Specification for Design, Construction, and Verification of Fixed-Wing Unmanned Aircraft Systems (UAS)

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F38 New Standards Under Development

WK65041 Practice for UAS Remote ID and Tracking

WK52089 New Specification for Operation over People

WK56338 Safety of Unmanned Aircraft Systems for Flying Over People

WK59171 SUAS parachutes

WK59317 Vertiport Design

WK60659 UAS Maintenance Technician Qualification

WK60937 Design of Fuel Cells for Use in Unmanned Aircraft Systems (UAS)

WK61763 Training for Remote Pilot Instructor (RPI) of Unmanned Aircraft Systems (UAS) Endorsement

WK61764 Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement

WK62416 Terminology Unmanned Aircraft Systems

WK62668 Detect and Avoid Performance Requirements

WK62669 Detect and Avoid – Test Method

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F38 New Standards Under Development

WK62670 Large UAS Design and Construction

WK62730 Practice for UAS Operator Audit Programs

WK62731 Practice for UAS Operator Compliance Audits

WK62733 Training and the Development of Training Manuals for the Unmanned Aircraft Systems (UAS) Operator

WK62734 Specification for the Development of Maintenance Manual for Lightweight UAS

WK62741 Training UAS Visual Observers

WK62743 Development of Maintenance Manual for Small UAS

WK62744 General Operations Manual for Professional Operator of Light Unmanned Aircraft Systems (UAS)

WK63407 Required Product Information to be Provided with a Small Unmanned Aircraft System

WK63418 Service provided under UAS Traffic Management (UTM)

2/12/2018

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ASTM Aligns Priorities to Industry & CAAs
Focus Area - Standards for Detect and Avoid

Standards Underway

- **WK62668** Specification for DAA Performance Requirements
  - *Defines minimum performance standards*
- **WK62669** Test Method for DAA
  - *Covering systems and sensors*

Scope of Work

- Applicable to smaller (<254 lbs)
- UAS BLVOS operations in lower altitudes (1200AGL)
- Protection of manned aircraft-UAS to manned aircraft encounters
- Defining well-clear and avoidance distances and/or times
- Regulatory constraints on ATC airspace and IFR ops
- Required to inform BVLOS standard practice

Define minimum performance standards & test methods for DAA systems and sensors applicable to smaller UAS BLVOS operations in lower altitude airspace.

ASTM Aligns Priorities to Industry and CAA
Focus Areas-Key Standards: BVLOS

F3196 Practice for Seeking Approval for Extended/Beyond Visual Line of Sight Operations (under revision FAA Pathfinder Program + Canadian Best practices)

Applications:
1) Package Delivery- *in progress*
2) Critical Infrastructure
3) Agriculture
4) Linear Inspection
5) Search and Rescue
6) Disaster Response (Hurricane Preparedness-2019)

WK62344 (Appendix to F3196) Mitigation for Package Delivery sUAS BVLOS

- Defining minimum requirements for safe /efficient use of currently available technology/equipage
- Develop the minimum requirements ensuring compatibility/interoperability between delivery providers
- Community Objective: Develop a sUAS vs manned aircraft Well Clear definition based on risk and operational suitability (Leverage lessons learned from large UAS well clear research)

Get Involved

F38 Unmanned Aircraft Systems

Attend Next Meeting

- Virginia Tech University
- 13-15 November 2018

Subcommittee Structure

- F38.01 Airworthiness
- F38.02 Flight Operations
- F38.03 Personnel Training, Qualification and Certification

Supporting ASTM Technical Committees

- F37 - Light Sport Aircraft
- F38 - Unmanned Aircraft Systems
- F39 - Aircraft Systems
- F44 - General Aviation Aircraft
- F46 - Aerospace Personnel
- F47 - Commercial Spaceflight
- E54.09 Response Robots

ASTM Membership

- **$75 USD per Year**
- **Access to Standards, Technical Documents and Information**
- **FREE** Volume of Standards – All Aircraft Standards in Volume 15.11
- The ability to vote on new standards and revisions to existing standards
- Receive current information on revisions to standards and new standards that can impact your business on a daily basis
- **Networking Opportunities, Leadership Growth and Recognition**
- **Click Here for More**

Anyone, anywhere in the world with an interest in the field covered, is eligible and welcome to join.

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** This material represents the views and positions of the presenter and not those of ASTM International and/or the entire ASTM F38 Committee*

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Questions/Discussion/ Backup Slides

www.astm.org

ASTM Autonomy Task Group

Task Group Objectives:

– Develop a short and long term strategy towards autonomy standards in ASTM
– Cross Cutting Task group
– Developing terminology, certification guidance & levels

Technical Committees:

– F37 - Light Sport Aircraft
– F38 - Unmanned Aircraft Systems
– F39 - Aircraft Systems
– F44 - General Aviation Aircraft

Integration of Automation Across Aviation

Swarms, cargo delivery, leading eventually to passenger service

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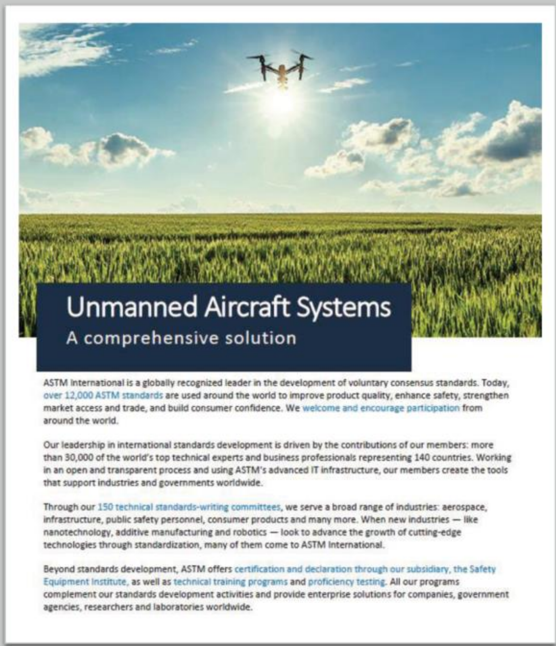
ASTM UAS Roadmap



Unmanned Aircraft Systems

A comprehensive solution

ASTM International is a globally recognized leader in the development of voluntary consensus standards. Today, over 12,000 ASTM standards are used around the world to improve product quality, enhance safety, strengthen market access and trade, and build consumer confidence. We welcome and encourage participation from around the world.

Our leadership in international standards development is driven by the contributions of our members: more than 30,000 of the world's top technical experts and business professionals representing 140 countries. Working in an open and transparent process and using ASTM's advanced IT infrastructure, our members create the tools that support industries and governments worldwide.

Through our 150 technical standards-writing committees, we serve a broad range of industries: aerospace, infrastructure, public safety personnel, consumer products and many more. When new industries — like nanotechnology, additive manufacturing and robotics — look to advance the growth of cutting-edge technologies through standardization, many of them come to ASTM International.

Beyond standards development, ASTM offers certification and declaration through our subsidiary, the Safety Equipment Institute, as well as technical training programs and proficiency testing. All our programs complement our standards development activities and provide enterprise solutions for companies, government agencies, researchers and laboratories worldwide.

**Available and updated on ASTM website URL:*
https://www.astm.org/COMMIT/ASTM%20UAS%20 Roadmap-1.pdf

International Engagement

Successful Case Study
- ASTM F44.92 Regulatory Liaison
- Global CAA's (ANAC, CAAC, CASA, EASA, FAA, TCCA,)
- Discuss Potential Harmonization
- Discuss Standards and Regulation Need
- Unified Communication back to Industry for Standards content

ASTM Aligns Priorities to Industry CAAs
Focus Areas-Key Standards-Ops Over People

WK52089 Specification for Operations over People

Design/Construction
- Quality assurance requirements
- Testing to verify the target reliability
- Software code control
- Redundant power supply, propulsion systems, communication and navigation
- Reliability

Risk Mitigation
- Operational Risk Assessment
- Parachute systems, airbags, human injury assessments, frangible design

Operations
- Pilot knowledge required for safe operations
- Route planning, risk minimization for ground and air hazards

ASTM Aligns Priorities to Industry and CAAs
Focus Areas- Key Standards-Ops Over People

WK59171 Parachute Recovery Systems for sUAS
(Summer 2018)

WK56338 Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts

- Based on research and testing conducted by the ASSURE program for FAA
- Three methods for evaluating the potential for impact injury:

  Method A: analytical method, suitable for lower weight, slower UAS with low impact energies

  Method B: simplified low cost test using instrumented head-forms and flight test to demonstrate failure modes and impact

  Method C: anthropomorphic test dummies to evaluate full human impacts for higher risk operations

ASTM Aligns Priorities to Industry & CAA
Focus Area – Key standards ORA

F3178 Operational Risk Assessment (sUAS)

- Will Support AC 21.17b Rewrite as AMOC
- <25 kg
- Documents CONOPS
- Identify , Quantify and Qualify operational hazards/harm
- Analyze the outputs of assessment
- Apply mitigations to satisfy safety of flight
- For access to airspace as regulated by respective CAA(s) either for *a: vehicle design (airworthiness), or a vehicle's use (operational approval)*

ORA/JARUS Specific Operations Risk Assessment (SORA):

- Different pathways – similar results
- SORA - Step by step approach for applicant
  - Standard scenarios will simplify process
- ORA – Traditional safety risk management process
- Both systems are acceptable means of compliance and should be used as appropriate for applicant

ASTM F38.03 Operator Standards

WK62744 General Operations Manual for Professional Operator of Light Unmanned Aircraft Systems (UAS)

- Best practices to support professional entities receiving operator certification by a CAA, and provide practice for self- or third-party audit of operators of UAS.

WK62730 UAS Operator Audit Programs

- Minimum requirements, responsibilities, qualifications for entities conducting internal audits against ASTM standards on Unmanned Aircraft Systems

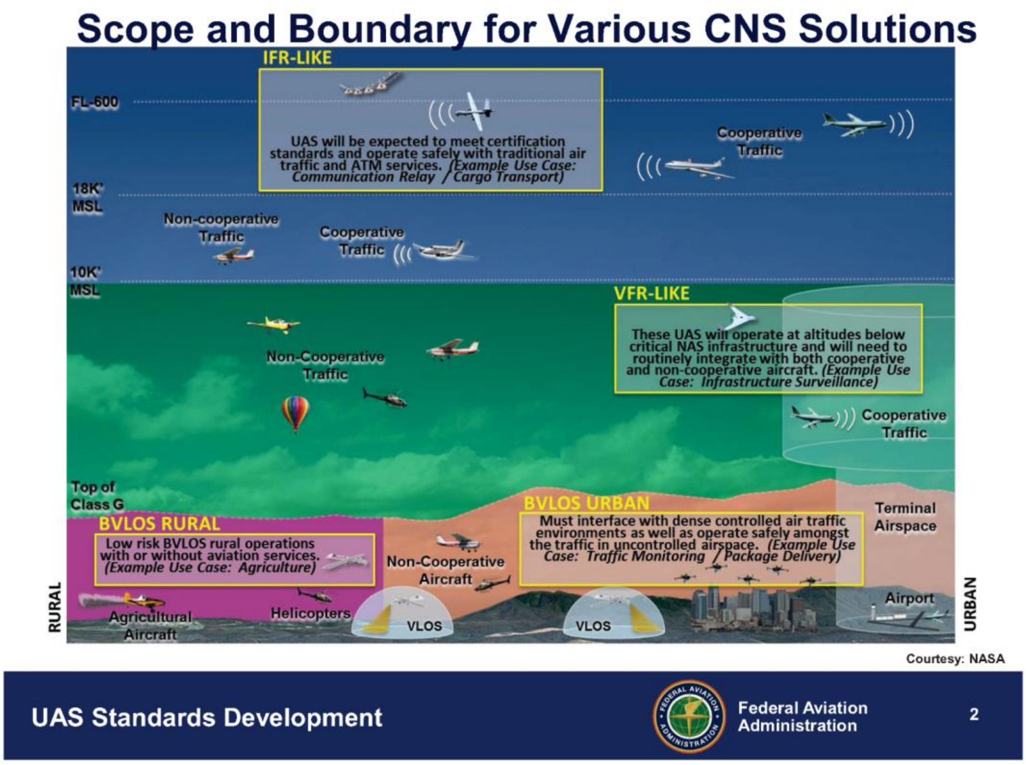
WK62731 UAS Operator Compliance Audits

- How to conduct a third party audit program for those who execute audits to meet the consensus set of minimum requirements and qualifications.

WK62733 Development of Training Manuals for the UAS Operator

附件 二、RTCA 簡報


Federal Aviation Administration
Unmanned Aircraft System (UAS) Standards Development
RTCA SC-228 Status
Stephen Van Trees, FAA
Presented to APAC UCWG
September 17, 2018


Scope and Boundary for Various CNS Solutions
IFR-LIKE
FL-600
UAS will be expected to meet certification standards and operate safely with traditional air traffic and ATM services. (Example Use Case: Communication Relay / Cargo Transport)
Cooperative Traffic
18K' MSL
Non-cooperative Traffic
Cooperative Traffic
10K' MSL
VFR-LIKE
These UAS will operate at altitudes below critical NAS infrastructure and will need to routinely integrate with both cooperative and non-cooperative aircraft. (Example Use Case: Infrastructure Surveillance)
Non-Cooperative Traffic
Cooperative Traffic
Top of Class G
BVLOS RURAL
Low risk BVLOS rural operations with or without aviation services. (Example Use Case: Agriculture)
BVLOS URBAN
Must interface with dense controlled air traffic environments as well as operate safely amongst the traffic in uncontrolled airspace. (Example Use Case: Traffic Monitoring / Package Delivery)
Terminal Airspace
Non-Cooperative Aircraft
Agricultural Aircraft
Helicopters
VLOS
VLOS
Airport
RURAL
URBAN
Courtesy: NASA
UAS Standards Development
Federal Aviation Administration
2

Overview

- Special Committee (SC)-228 Leadership
- Terms of Reference
- Detect and Avoid (DAA) Status
  - Architectures Overview
  - White Papers
- Command and Control (C2 Link) Status
  - Architectures Overview
  - White Papers

SC-228 WG1

Co-Chairs - John Moore, Rockwell Collins
Paul McDufee, Boeing

Government Authorized Representative - Steve Van Trees, FAA
Secretary – Kristina Carr, FAA ANG

Detect and Avoid (DAA) Working Group, WG-1

- Co-Lead – Ted Lester, MITRE
- Co-Lead - Don Walker, Honeywell
- Secretary – Paul Campbell, FAA UAS Integration Office

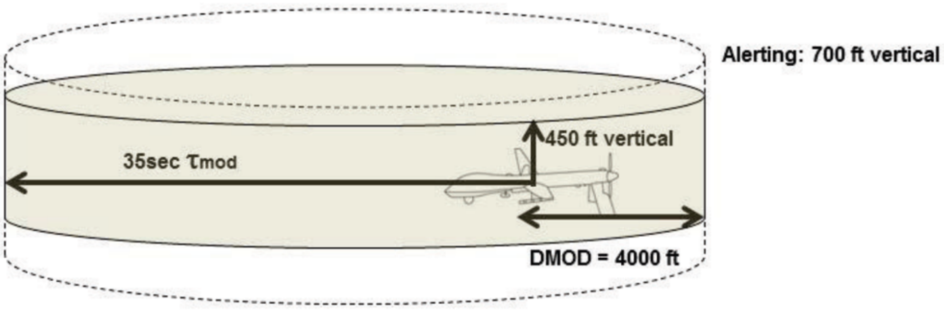
Total Membership = 479 Members as of May 9, 2017

Terms of Reference (TOR) Milestones

Original TOR written to support FAA UAS ConOps v2.0
TOR Updated for Phase Two on Sept 22, 2016

Steps \ Phases	Phase One		Phase Two	
	DAA	**C2**	**DAA**	**C2**
White Papers	Dec 2013		July 2017	
Verification & Validation	July 2015		N/A	
DAA/C2 MOPS	Dec 2016	July 2016	Sept 2020	July 2020
Radar MOPS	Dec 2016		Sept 2019	
SATCOM MASPS				Oct 2017
NETWORK MASPS				July 2018
SATCOM MOPS				Jan 2019

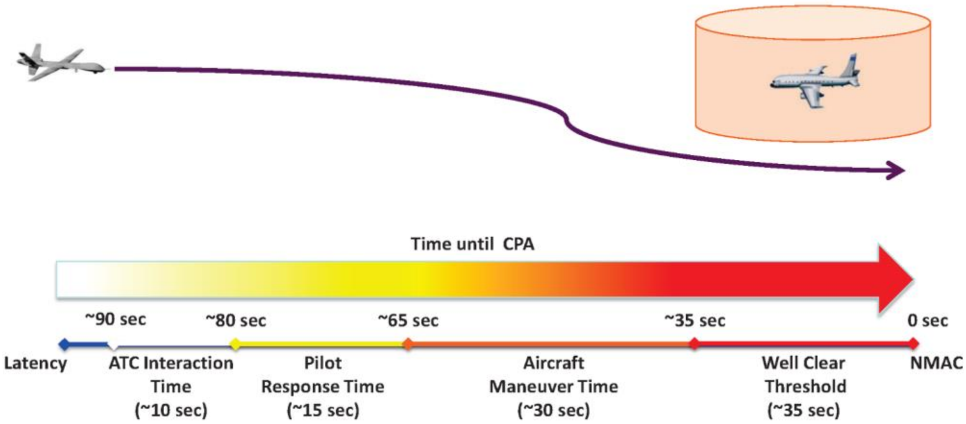
SARP DAA Remain-Well-Clear Definition



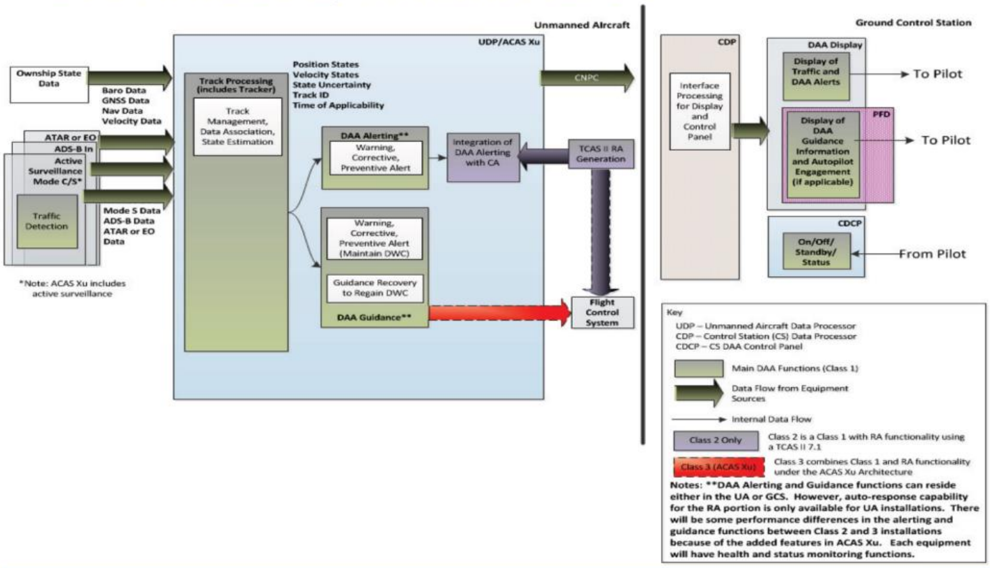
DAA Well-Clear is a temporal and/or spatial boundary around the aircraft intended to be an electronic means of avoiding conflicting traffic.

* Future phases of work will consider the SARP definition for DAA for small, lower altitude UAS

DAA Maneuver Timeline



Airborne Sensors – Class 1, 2, 3
DAA Phase 2, Architecture 1



DAA and Radar MOPS Update

- DO-365, DAA MOPS, and DO-366 Air-to-Air Radar MOPS, issued May 31, 2017
- FAA Aircraft Certification office indicated that DO-365 and DO-366 will be invoked through:
  - TSO c-211 and TSO c-212
  - AC 20-DAA
- FAA SRM Panel completed to provide approval for operations in Class D and E Airspace using either Class 1 or Class 2 DAA equipment

Successful Ikhana Flight in LAX airspace.

June 12, 2018

NASA Flies Large Unmanned Aircraft in Public Airspace Without Chase Plane for First Time

- Flights of large craft like Ikhana, have traditionally required a safety chase aircraft to follow the unmanned aircraft as it travels through the same airspace used by commercial aircraft.
- The Ikhana flew in accordance with the Federal Aviation Administration's (FAA) Technical Standard Order 211 -- Detect and Avoid Systems -- and Technical Standard Order 212 -- Air-to-Air Radar for Traffic Surveillance.
- This flight was the first remotely-piloted aircraft to use airborne detect and avoid technology to meet the intent of the FAA's "see and avoid" rules, with all test objectives successfully accomplished.

For more information, visit: https://www.nasa.gov/press-release/nasa-flies-large-unmanned-aircraft-in-public-airspace-without-chase-plane-for-first

White Papers – DAA Phase 2

- **Operational Services and Environment Description (OSED)**
  - Extended operation in Class D, E, G
  - Visual Clearance equivalence
  - Terminal Area
  - Transit operations in Class B, C
  - International Harmonization
- **Alerting and Guidance**
  - DAA Well Clear tailoring
  - Aircraft Performance analysis of smaller UAS
  - Automation of traffic avoidance
- **Architecture**
  - System Architecture and Equipment Classes
  - Effects of C2 performance including SATCOM
  - Alternative Antenna designs
  - ACAS Xu Implementation
- **Sensors**
  - Ground Based non-cooperative RADAR
  - Electro-Optical and Infrared
  - Lower performance airborne RADAR
- **Verification and Validation**

DAA Operational Environments for Phase 1 (Blue) and Phase 2 (Green)

	Terminal Operations	Transit Operations	Extended Operations
Class A	No	Yes*	Yes*
Class B	No	See Note	No
Class C	See Note	See Note	No
Class D	Yes	Yes	Yes
Class E	Yes	Yes	Yes
Class G, off-airport	Yes	Yes	Yes
Class E above A	No	No	No
Oceanic, Class A	No	Yes*	Yes*

Note: Final TOR to PMC: The operational environment for the MOPS in Phase One is the transitioning of a UAS to and from class A or Special Use Airspace, traversing Class D, E, and G airspace. The operational environment for the MOPS in Phase Two is extended UAS operations in class D, E, and G airspace, takeoff and landing operations in class C, D. E. and G airspace, and transit through Class B airspace.

Proposed DAA WG P2 Deliverables
(Maintains intent of TOR while providing more granularity)

Product	Description	Due Date
Ground-based Primary Radar MOPS	MOPS for a ground-based non-cooperative radar to support the Phase Two DAA MOPS.	September 2019
DAA MOPS, DO-365, Rev A	Revision to the DAA MOPS that incorporates at least the Ground-based Non-Cooperative Radar MOPS including architectural considerations and operational concepts.	September 2019
Airborne EO/IR Sensor MOPS	MOPS for an alternative sensor to detect and track non-cooperative aircraft in support of the Phase Two DAA MOPS.	September 2020
Air-to-Air Radar MOPS, DO-366, Rev A	Revision to the Airborne Radar MOPS in support of the Phase Two DAA MOPS.	September 2020
DAA MOPS, DO-365, Rev B	Revision to the DAA MOPS that incorporates at least DO-366A including architectural considerations and operational concepts and ACAS XU.	September 2020
Note: ACAS XU MOPS due Sept. 2020 according to SC-147 TOR, in conjunction with DO-365, Rev B		

WG1 is capitalizing on strong response from airborne sensor developers (EO/IR and Radar) and is planning to include both as means to enable UA with less available SWAP.

SC-228 WG2

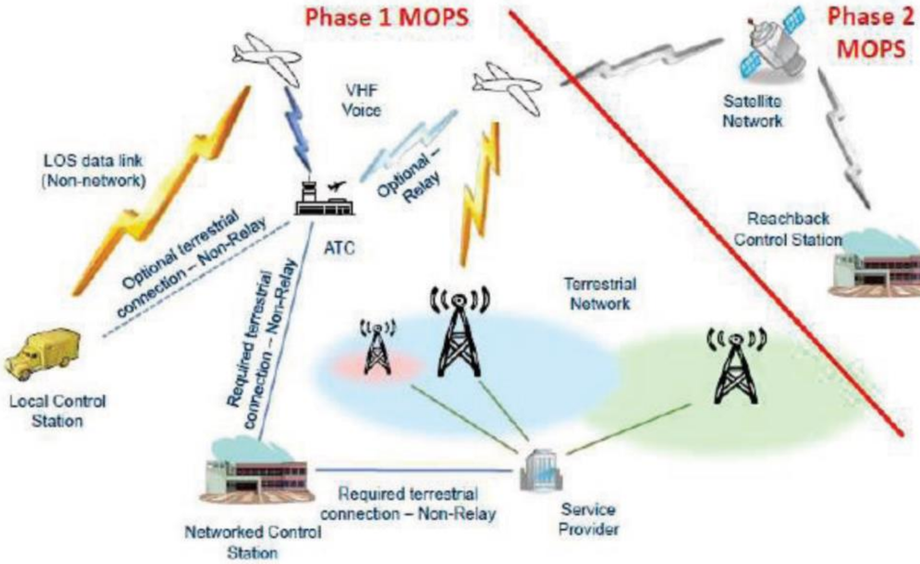
Co-Chairs - John Moore, Rockwell Collins
Paul McDufee, Boeing

Government Authorized Representative - Steve Van Trees, FAA
Secretary – Kristina Carr, FAA ANG

Command and Control (C2) Working Group, WG-2
- Co-Lead – Jim Williams, JHW Unmanned Solutions
- Co-Lead - Steve Van Trees, FAA Aircraft Certification
- Secretary – Lee Nguyen, FAA Aircraft Certification

Total Membership = 479 Members as of May 9, 2017

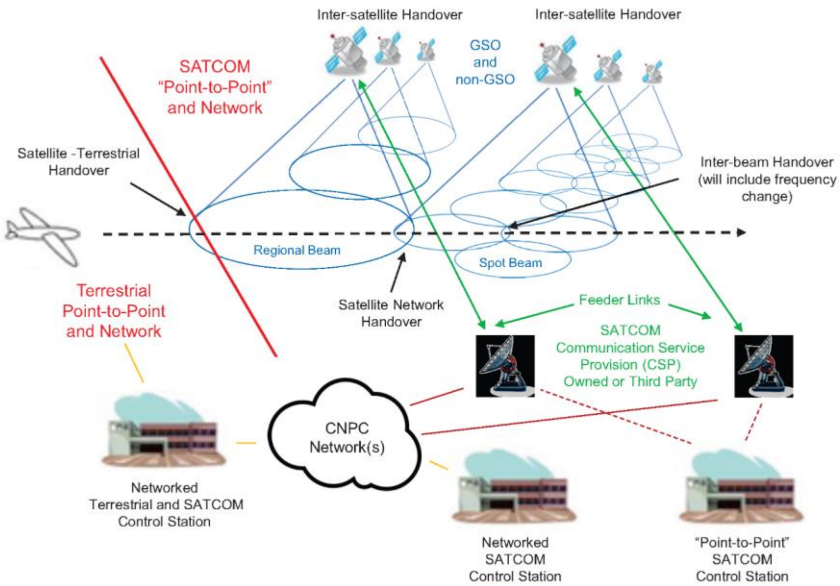
Phase 1 Architecture – Point-to-Point



DO-362 C2 Data Link MOPS Update

- **DO-362, C2 Data Link MOPS (Terrestrial) was issued 22 September 2017**
- **FAA Aircraft Certification office indicated that DO-362 will be invoked through:**
  - TSO-c213
  - AC 20-187

Phase 2 Architecture - SATCOM



White Papers – C2 Phase 2

- **Phase 2 focused on extensions to point-to-point architecture to expand beyond Radio Line of Sight operations**
- **Develop MASPS level documents to support Top Down safety analysis driven performance metrics**
- **Primary Focus is SATCOM architectures**
  - Ku and Ka bands are in-scope
  - C band is possibility
- **Develop performance standards for network of C2 radios**
- **Update existing L and C band document with data from on-going research**
- **Evaluate use cases for smaller UAS**
  - Dependency on FAA supported operations

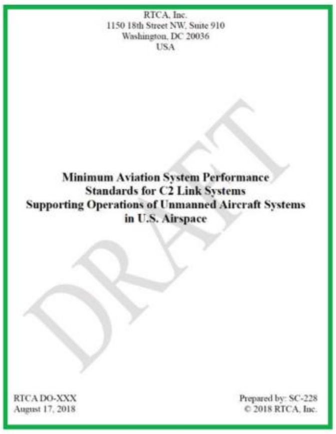
Proposed C2 WG P2 Deliverables
(Maintains intent of TOR while providing better decomposition)

Deliverable Document	FRAC Completion
C2 Link Systems MASPS	December 2018
CNPC Link System MASPS (SATCOM)	June 2019
C2 Link System MASPS Rev A	December 2019
CNPC Link System MASPS (SATCOM) Rev A	March 2020
CNPC Link System MOPS (Terrestrial) DO-362 Rev A	June 2020

UAS Standards Development — Federal Aviation Administration — 19

Purpose of the C2 Link MASPS

- Provide guidance recognized by the FAA for UAS OEM's, Avionics Manufacturers, and communications service providers on acceptable design, test, and operation of C2 Link Systems used for BVLOS operations throughout the NAS.
- The Small Airplane Directorate and the Rotorcraft Directorate are essential to achieving this goal
- Establishing FAA Accepted levels of risk during UAS certification is key aspect of this MASPS


RTCA, Inc.
1150 18th Street NW, Suite 910
Washington, DC 20036
USA

Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace

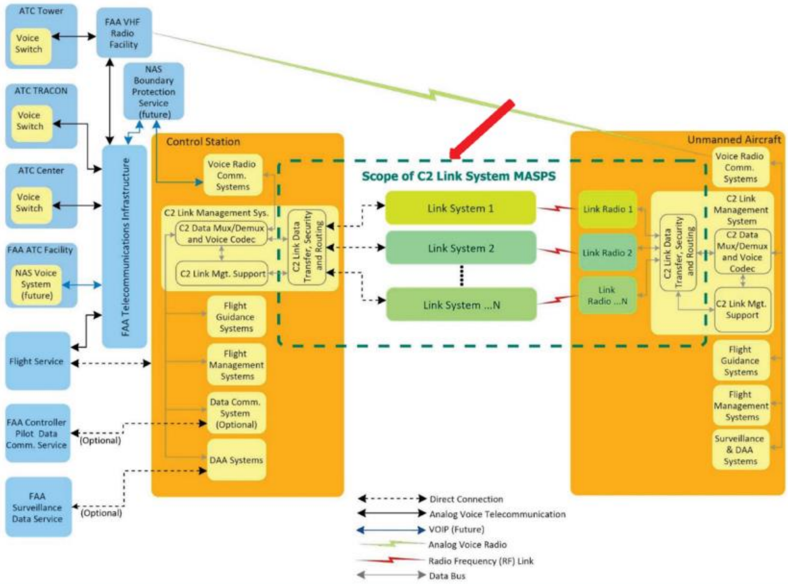
DRAFT

RTCA DO-XXX
August 17, 2018

Prepared by: SC-228
© 2018 RTCA, Inc.

UAS Standards Development — Federal Aviation Administration — 20

Scope of C2 Link System MASPS



UAS Standards Development | Federal Aviation Administration | 21

Approach to Safety Risk

- Define the system – C2 Link SV-2
- Define assumptions and bound system
  - Linear Sensing – Power Line Inspection
  - Aerial Survey Work-Media and Incident Reporting
- Identify potential hazards
  - Based on the operational use
  - Defined in the CONOPS and OSED
  - Derived from "Information exchanges and actions" (described in the OV-3)
- Identify environment or system state (described in OV-3)
- Analyze the system
  - Identify existing controls
  - Determine possible effect(s)
- Assess the severity of each hazard
- Use risk matrix to determine Safety Objective
- Identify possible mitigations (document in OPA as performance requirements)

Appendix D
D-19

Table D-7: Initial Risk Matrix

Severity / Safety Objective	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	22 Hazards				
Probable B		6 Hazards			
Remote C			12 Hazards		
Extremely Remote D				C1-S1-UCA4d C1-S1-UC1.2 C1-S1-UC3.1a C1-S1-UC3.1b C1-S1-UC6.1 C2-S1-UC1.6a C2-S1-UC4.6	
Extremely Improbable E					* C1-S1-UC3.[illegible] C1-S1-UC6.2 C2-S1-UC1.6b

High
Medium
Low

* Risk is high when there is a single point or common cause failure.

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OSA Objective

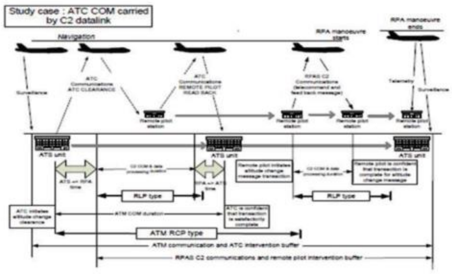
- Primary objective of the OSA is to establish safety objectives which are documented as performance requirements in the Operations Performance Analysis (OPA)
- Developed safety objectives for each identified hazard
- Severity of each hazard was identified first
- Safety objectives were established based on the allowable likelihood needed to ensure an acceptable level of safety risk
- Purpose of the safety objectives is to ensure safety risk is acceptable: less than or equal to medium.

Table D-6: Hazardous and Catastrophic Hazards Summary

Hazard No.	Hazard Description	Initial Risk	Safety Objective
C1-S1-UC-A4d	Remote pilot and/or UA are receiving inaccurate C2 Link System status information.	Hazardous	Extremely Remote
C1-S1-UC1.2	Corrupted data causes the UA to deviate from the intended Flight Plan.	Hazardous	Extremely Remote
C1-S1-UC3.1a	Remote pilot does not receive the warning alert in a timely manner. (Controlled airspace).	Hazardous	Extremely Remote
C1-S1-UC3.1b	Incorrect information is received at the CS.	Hazardous	Extremely Remote
C1-S1-UC6.1	Remote pilot does not receive the warning alert in a timely manner. (Uncontrolled airspace).	Hazardous	Extremely Remote
C2-S1-UC1.6a	Remote pilot takes off to an unexpected altitude.	Hazardous	Extremely Remote
C2-S1-UC4.6	Incorrect route is activated.	Hazardous	Extremely Remote
C1-S1-UC3.2	Inadequate or lack of maneuver when one is required (Controlled airspace).	Catastrophic	Extremely Improbable
C1-S1-UC6.2	Inadequate or lack of maneuver when one is required (Uncontrolled airspace).	Catastrophic	Extremely Improbable
C2-S1-UC1.6b	UA does not follow the expected route to the designated departure point (Flyaway).	Catastrophic	Extremely Improbable

OPA Approach

- **Determine the C2 Link Performance Drivers for use cases that are the most stressing for the C2 Link**
  - Which of the five pilot's tasks will be most demanding for each phase of flight?
  - What Performance Attributes will be assessed (Availability, Continuity, Integrity, Transaction Expiration Time, Latency)?
- **What Use Case can we use to assess the required performance?**
- **Develop a timeline for the chosen Use Case to determine TET**
  - DAA = "Do over" of Phase 1
  - Voice Comm. = new, consider combining Surveillance with ATC initiated lateral or vertical maneuver to avoid traffic
- **What Operational and Security Hazards can occur?**
  - Lost C2 Link?
  - Jamming?



Approach to Risk and Design Assurance

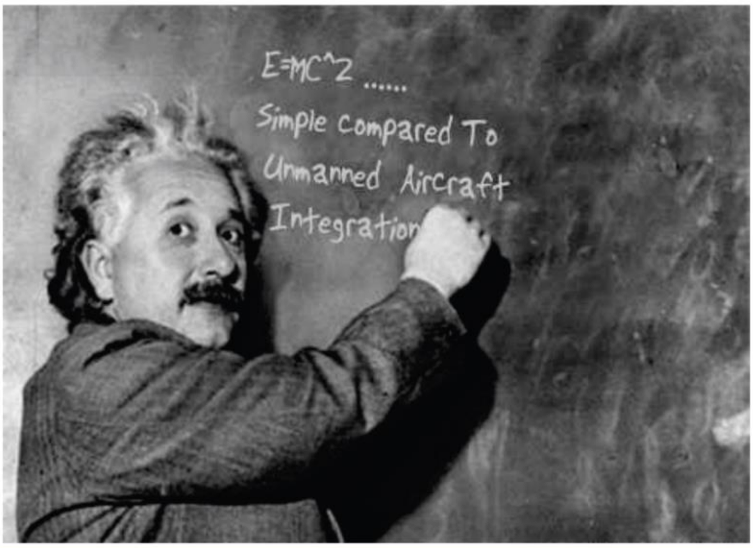
- Requirements stated in Qualitative Terms (e.g. remote) because variation in quantitative values will be established during aircraft certification process (or future regulations)
- Risk Matrix included with explanation of how it will be used in cert process
- Risk Class 3 Example tables included in MASPS with appropriate cautions about making assumptions
- This approach is consistent with the FAA risk based certification approach as defined in the "FAA and Industry Guide to Product Certification"

Table E-2: Risk Matrix

RISK MATRIX				
Severity	Minor	Major	Hazardous	Catastrophic
Safety Objective Allowable Qualitative Probability	Probable	Remote	Extremely Remote	Extremely Improbable
Risk Class of UAS	Allowable Quantitative Probability, and Primary System Software and Hardware Design Assurance Levels			
Risk Class 1 (<=529 ft lb of kinetic energy)	$< 10^{-1}$ DAL E	$< 10^{-2}$ DAL E	$< 10^{-3}$ DAL E	$< 10^{-4}$ DAL E
Risk Class 2 (>=530 to <=24,999 ft lb of kinetic energy	$< 10^{-2}$ DAL E	$< 10^{-3}$ DAL D	$< 10^{-4}$ DAL D	$< 10^{-5}$ DAL D
Risk Class 3 (>=25,000 to <=799,999ft lb of kinetic energy	$< 10^{-3}$ DAL E	$< 10^{-4}$ DAL D	$< 10^{-5}$ DAL D	$< 10^{-6}$ DAL C
Risk Class 4 (>=800,000 to <=5,999,999 ft lb of kinetic energy	$< 10^{-3}$ DAL D	$< 10^{-5}$ DAL C	$< 10^{-6}$ DAL C	$< 10^{-7}$ DAL C no single failure
Risk Class 5 (>=6,000,000 to <=49,999,999 ft lb of kinetic energy	$< 10^{-3}$ DAL D	$< 10^{-5}$ DAL C	$< 10^{-7}$ DAL C	$< 10^{-8}$ DAL B no single failure
Risk Class 6 (>=50,000,999 ft lb of kinetic energy	$< 10^{-3}$ DAL D	$< 10^{-5}$ DAL C	$< 10^{-7}$ DAL B	$< 10^{-9}$ DAL A no single failure

Note E-7: This table should be used as a baseline level of safety and should be adjusted during the process of establishing the certification basis for a specific UA. The actual kinetic energy calculation requirements applicable to a specific UA will vary with type of UA, the speed of the UA and any features on the UA used to limit kinetic energy after power plant failure (e.g., parachute).

Discussion!



附件 三、紐西蘭案例簡報


Case study: future A-B
DISCLAIMER: Fictional operation, figures & images are not representative


Air taxi A-B flight
Power: All-electric
Capacity: Designed for two passengers.
Altitude: Operates between 500 ft to 3000 ft above the ground (150 m to 900m).
MCTOW: 2,700 lb (1,224 kg)
Wingspan: 36 feet (11 m)
Vertical take-off and landing: 12 independent lift fans, which enable VTOL and transition to forward flight
Range: Approx. 60 miles (100 km)
Speed: Approx. 180 kph (100 knots)
Assumption: Controlled & Uncontrolled airspace
DISCLAIMER: Fictional operation, numbers and images are not representative

Airworthiness Requirements

Apply FAR 21.17(b) style approach
Manufacture in a certificated organisation (CAR Part 148)

14 CFR 23 Normal Category Airplanes (ASTM F44) → Airplane certification levels:
(1) Level 1—for airplanes with a maximum seating configuration of 0 to 1 passengers.
(c) Airplane performance levels:
(1) Low speed—for airplanes with a VNO and VMO ≤ 250 Knots Calibrated Airspeed (KCAS) and a MMO ≤ 0.6.

14 CFR 27 Normal Category Rotorcraft → Or eVTOL (ASTM WK53964 in development)

EASA E.Y013-01 Policy Statement on UAS Certification → SC-RPAS on Remote Pilot Station, C2, flight control, flight (<u>but VLA/VLR only</u>)

Unique Special Conditions

CAA

Airworthiness Gaps / Special conditions

- DAA (ASTM F38.01, EUROCAE WG105, RTCA)
- Passenger comm's/ handling/ equipment
- Ballistic parachute (81 FR 14801) (LSA F2316 – requires pilot on board)
- C2Link / Control Station / Software?
- e-propulsion (ASTM F44 F3316 & WK58700 Electrical Systems for Aircraft with Electric or Hybrid-Electric Propulsion)
- Emergency recovery/management
- Energy storage? / Cell containment
- Flight test

CAA

ASTM F38.01 (UAS) Airworthiness

DESIGNATION	TITLE
F2851	Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)
F2910	Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)
F2911	Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS)
F3002	Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)
F3003	Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)
F3005	Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)
F3201	Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)
F3269	Practice for Methods to Safely Bound Flight Behavior of Unmanned Aircraft Systems Containing Complex Functions
WK16285	Specification for Specification for Design and Performance of an Unmanned Aircraft System-Class 1320 (550# Gross Weight to 1320# Gross Weight)
WK27055	Practice for UAS Remote ID and Tracking
WK53964	Design, Construct, and Test of VTOL
WK52089	Specification for Operation over People
WK56338	Safety of Unmanned Aircraft Systems for Flying Over People
WK59171	SUAS parachutes
WK60936	Acoustic-based Detect and Avoid for sUAS
WK60937	Design of Fuel Cells for Use in Unmanned Aircraft Systems (UAS)
WK57659	Design, Construction, and Verification of Fixed-Wing Unmanned Aircraft System (UAS) Standard
WK62670	Specification for Large UAS Design and Construction
WK62668	Specification for Detect and Avoid Performance Requirements
WK62669	Test Method for Detect and Avoid

sUAS

EASA PS E.Y013-01

Table of Contents:

SC-RPAS.FC	Flight control
SC-RPAS.RPS	Remote pilot station
SC-RPAS.C2	Command & Control
SC-RPAS.SubpartB	Flight